THE EFFECTS OF FIRE ON *PENSTEMON LEMHIENSIS* - MONITORING ESTABLISHMENT REPORT 1995 and 1996

By

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EXECUTIVE SUMMARY

Lemhi penstemon (*Penstemon lemhiensis*; G3 S2) is a regional endemic plant species of Idaho and adjoining Montana whose largest monitored population sites in Montana have shown sharp declines since 1989. This documentation, anecdotal observations of its responses to fire and other surface disturbances, and its pattern of distribution are the basis for hypothesizing that it favors or requires periodic fire disturbance to persist.

This study was initiated to reintroduce fire disturbance and determine species' responses. The specific monitoring objective is to determine the demographic response of *Penstemon lemhiensis* after prescribed burn treatment, monitoring it at annual intervals for a minimum of four years after treatment on three sites that are considered critical for conservation of the species throughout its range. This report documents the study site selection, methods, and data from 1995 and 1996 in monitoring the effects of fire on *Penstemon lemhiensis* in Beaverhead County, Montana.

Acknowledgments

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INTRODUCTION

This report documents the methods, study site selection, and data from the first two years in monitoring the effects of fire on *Penstemon lemhiensis*. It is designed to foster the conservation strategy goal of restoring and maintaining large populations on the landscape (Elzinga 1995).

Lemhi Penstemon (*Penstemon lemhiensis*) is a perennial herbaceous plant species and a regional endemic known from four counties in Montana and from Lemhi County in Idaho. It is recognized as sensitive by Region 1 of the U.S. Forest Service (USDA FS 1994) and by Montana State Office of the Bureau of Land Management (USDI BLM 1996). It is ranked "G3" (globally vulnerable), and "S2" (state imperiled) by the Montana Natural Heritage Program. The latter is based on the provisional interpretations that its occurrences while in excess of 20 are clustered and may be interdependently linked as metapopulations, that there are downward trends among them, and that the numerous, small occurrences in artificially-disturbed settings are short-lived and make little or no contribution to overall species' viability.

Demographic monitoring studies have identified critical life history stages. It is an herbaceous perennial with episodic flowering and an undetermined minimum number of years to first flowering. It produces single or multiple terminal buds that become rosettes, and no more than one flowering stalk is produced per rosette. Seedling establishment is the single most critical stage in species life history for the maintenance of populations (Shelly and Heidel 1995). No individuals among the 192 seedlings observed over 4-6 years matured from seedling to flowering plants and most died before becoming established.

Ramstetter (1983) found that *Penstemon lemhiensis* is negatively associated with high vegetation cover, which may reflect seedling establishment requirements. This is consistent with previously-mentioned monitoring results in that seedling establishment is lowest at the monitoring site having highest cover of sagebrush (Badger Pass North).

Lemhi penstemon is considered likely to be an increaser under at least some fire conditions, based on qualitative observations after a wildfire in Salmon National Forest and after a prescribed burn for vegetation management in Big Hole National Monument. At the latter, the burned area was observed to have more *Penstemon lemhiensis* a decade after the burn than before treatment, and the species disappeared from an adjoining untreated area (Pierce pers. commun.). Curtailment of wildfires has been postulated as contributing to rangewide species decline (Moseley et al. 1990), and management response to prescribed burn treatment has been identified as one of three key research questions in developing effective species' conservation (Elzinga 1995).

Downward trends have been documented in segments of two large occurrences without habitat manipulation (Shelly and Heidel 1995; French Creek - Park Mine, Badger Pass North). More stable trends (small increases or decreases) have been documented at nearby sites with moist microhabitat, or cooler conditions (French Creek - Discovery Mine, Badger Pass Microwave

Tower). Small occurrences in disturbed roadside right-of-way settings, such as the Horse Prairie belt transect, are considered to be short-lived phenomena (Heidel and Shelly 1993). Between 1991 and 1996, the numbers of plants in the Horse Prairie transect went from 39 to 0. These sample sets were not randomly placed to represent the population as a whole, but were subjectively placed in population segments of highest density for stastical analysis of demography. We have not found evidence that core populations are intrinsically unstable and mobile. Instead, we have found evidence to support the hypothesis that the species may be at risk in the absence of natural fire disturbance to create habitat for establishment and recruitment (Shelly and Heidel 1995.)

Fire regimes have been greatly altered throughout the species' range. The fire frequencies in one of this species' primary habitats of southwestern Montana, at the *Pseudotsuga* forest-grassland ecotones, was 35-40 years prior to 1910, and presumed shorter in grassland proper (Arno and Gruell 1983). Early journalists in the area noted that fire enhanced grasses and inhibited growth of woody plants (Gruell 1985). The fire frequency throughout its range has diminished with settlement. It has been interpreted that the high valleys and foothills of southwestern Montana have converted from a predominantly grassland vegetation types where sagebrush dominance was restricted to soil texture extremes (sands, gravels, clays) to a landscape dominated by sagebrush, primarily *Artemisia tridentata*, in absence of fire (Arno and Gruell 1983).

Throughout the Montana portion of *Penstemon lemhiensis* distribution, the historic practice of private landowners and federal land managing agencies has been one of fire suppression as dictated by habitat flammability and limited programs for prescribed fire management. This history and pervasiveness of fire suppression confounds experimental efforts to replicate the natural fire disturbance regime on a small scale because of long-standing and extensive successional shifts in composition and structure. Such difficulties of and imperatives for researching the effects of fire on threatened and endangered plants are briefly reviewed by Hessel and Spackman (1995).

The immediate monitoring objective is to determine the demographic response of *Penstemon lemhiensis* after prescribed burn treatment, monitoring it at annual intervals for a minimum of four years after treatment on three sites. The goal is to contribute to the restoration and maintenance of three of the ten Montana occurrences of *Penstemon lemhiensis* that are considered critical to the maintenance of the species geographic distribution and viability in the state (Elzinga 1995). It will also provide rangewide restoration and management information.

A separate but parallel study was initiated in cooperation with the USDA Forest Service Shrub Sciences Laboratory in Provo, Utah to conduct germination trials to identify optimum germination conditions. It provides the basis for planning treatment to minimize impact to germination and establishment.

STUDY AREAS

The three sites selected in this study represent segments of three of the ten Montana populations that have ever been recorded with numbers of individuals in excess of 100 and that were identified as critical in maintaining species' geographic distribution and viability rangewide (Elzinga 1995.) They encompass over 50% of population numbers at the three sites when they were first established, and they represent a range of typical habitats in Beaverhead County.

Two of the study sites are sites of pre-existing demographic monitoring sites, including Badger Pass North on the Dillon District of Beaverhead National Forest and Badger Pass Microwave Tower Exclosure on the Dillon Resource Area of the Bureau of Land Management. The third site on Canyon Creek was identified by the District and slated for experimental prescribed burn on the Wise River District of Beaverhead National Forest. We also considered including the French Creek population, which includes two monitoring stations (Discovery Mine and Park Mine), but it occurs in habitat similar to that of the Badger Pass North site, and has more logistical difficulties in conducting prescribed burning.

The greatest concern was finding sites with *Penstemon lemhiensis* present in sufficient numbers and densities to generate statistically rigorous response data regardless of increase or decline. The pre-existing demographic monitoring belt transects were used at the Badger Pass North and Badger Pass Microwave Tower Exclosure, encompassing peak numbers and density within the respective occurrences. The Badger Pass North belt transect was set up in 1989 (Shelly 1990) following the methods described by Lesica (1987). It had high documented density (>2 individuals/meter) and the numbers have plummeted (Shelly and Heidel 1995). The Badger Pass Microwave Tower Exclosure set of transects were set up in 1991 (Achuff 1992) by similar methods. It has the highest persisting density of plants in the state (between 1-2 individuals/meter) and its numbers are relatively stable (Shelly and Heidel 1995). The history of demographic monitoring in belt transects at these two sites provides an expanded historical baseline for post-treatment analysis.

The third monitoring site is a new one on Canyon Creek identified by Beaverhead National Forest personnel in coordination with others. Plot location and description information is presented in Appendix A, and establishment information is presented in the following discussion of methods.

METHODS

Our goal is to detect all changes in the numbers of individuals by life history and reproductive class (seedling, non-flowering plant, flowering plant) within the sample plots and the transitions between them, in order to assess the response of mortality, recruitment, and fecundity to fire. Other parameters relating to vigor, fecundity and herbivory were also measured.

Sample numbers in the two belt transects were inadequate to divide the transects into separate treatment/control comparisons. The only site with a potential on-site control is at the new site on Canyon Creek, although the two sample sets have different population densities and canopy cover. Since on-site controls were not possible, the study was designed for comparison over time. This requires correlating sampling results with meteorological data, which is monitored at stations in Dillon and Wisdom. Key data include annual precipitation by month compared to a 30-year average, and monthly minimum temperature through the growing season.

We questioned whether the existing belt transects would be adequate to gauge short-term seedling trends. Seedling recruitment usually takes place close to parent plants, as observed during demographic monitoring. The existing belt transects have high proportions of "edge" (20% of the subplot is within 0.1 m of the belt margins), potentially skewing seedling results. There was not a practical way to include more plants by expanding the belt boundaries. To minimize edge affects and take in alternate local microhabitats, we added 10 x 10 m quadrats at both belt transect sites in the highest density population segment that we could find out side of the belt transects. We put in two quadrats at Canyon Creek, which together encompasses peak numbers and density. Individuals within the 100 1 x 1 m2 subplots are mapped by their quadrat coordinates and subplot coordinates. The x-axis is at the bottom of the plot running parallel to the slope, and the y-axis runs perpendicular to the slope.

To summarize, sampling was established in two sets at three different sites. We chose permanent plots because we had data to suggest that populations were relatively stable in their location over time. The sample sets reflect four different profiles. A qualitative descriptions of the six samples sets is summarized below.

Profile / Site	
High density, low flowering -	Badger Pass Microwave Belt Transect
Mid density, low flowering -	Canyon Creek West
Low density, high flowering -	Badger Pass Microwave Quadrat
Low density, low flowering -	Badger Pass North Belt Transect, Badger Pass North Quadrat, Canyon Creek East Quadrat

All three of the sample sets with low density and low flowering are in settings with high sage cover, though the settings differ among the three. The only valid comparisons that can be made between data sets are within identical sample sets over time.

Monitoring data were collected on August 17 and 18, 1995 and August 19 and 20, 1996 in the two belt transects and four new quadrats. The existing demographic monitoring belt transects were re-read at Badger Pass Microwave (three short transects plus marked plants), and at Badger Pass North (one transect), as presented in Achuff (1992) and Shelly (1990), respectively. These belt transects are marked by orange-sprayed rebar endpoints along the lower (downslope) side of the belt. They were read by stretching a tape between the endpoints, and using two one-meter calibrated measuring sticks for taking the subplot reading.

Four 10 x 10 quadrats were permanently established (two at Canyon Creek, one at Badger Pass North, and one at Badger Pass Microwave) in July, 1995 by the authors together with an interagency team that included the fire boss for all burn treatments. The *Penstemon lemhiensis* individuals were conspicuous at this time of season. Quadrats are marked by orange sprayed rebar at all four corners. They are read by stretching two tapes along the top and bottom of the plots (parallel to the hill slope), and stretching a third tape between the upper and lower tapes. The 1x1meter square subplots are delimited using a pair of one-meter calibrated measuring sticks. The quadrats were read facing uphill, moving up the Y-axis for clear viewing and maximum attention to avoid trampling plants in adjoining subplots. Plot and transect markers were resprayed between years as needed.

Baseline vegetation and ecological data were collected on ecodata forms from macroplots centered in the quadrats (Appendix B). Vegetation and soils information will be re-collected in the year immediately following burn treatment.

Permanent pre-burn photographic records were taken later at monitoring time using a 25 mm lens situated at the lower lefthand corner of the plot and positioned at head height (ca. 1.7m). Photographs were taken of the x-axis and y-axis lines, and the center of the plot looking diagonally to the far corner (Appendix C). The photographs will be re-taken in the year immediately following burn treatment.

Mature individuals of *Penstemon lemhiensis*, both flowering and non-flowering, were mapped within each of the 100 1 x 1 meter square subplots in each gridded quadrat. In 1995, the number of seedlings and small, immature rosettes present within a 1 m2 radius around each flowering plant was counted as a means of estimating the pretreatment level of establishment. In 1996, exhaustive documentation was made of seedlings and small rosettes throughout. This means that 1995 numbers for the smallest plants are incomplete in the quadrats and cannot be compared with 1996 results. The growth form of each individual was recorded using the following codes:

-Seedling=S (cotyledons evident, or rosette less than 15 mm diameter)
-Rosette=R, followed by the number of rosettes
-Flowering plants were indicated as such by added information after the number of rosettes, including I=number of infloresences, B=number of browsed infloresences, F=number of matured or maturing fruits, A=number of aborted flowers failing to set seed.
-A small rosette category "C" was created for established, immature plants (4 or fewer leaves)

The total number per plant for each life history characteristic was also recorded; thus, a plant with 5 basal rosettes, 2 infloresences, 17 fruits and 25 aborted flowers was recorded as R5I2F17A25.

Multi-rosette plants sometimes have small rosettes in the "S" or "C" size class, which are noted as part of the individual plant when they are recorded. However, they signify a disparity between the size class and life history definitions of seedlings and rosettes. To differentiate in the data between new seedlings and tiny seedling-sized buds on existing plants, we added a "true seedling" (TS) category. To tally all of the discrete terminal buds of a given plant regardless of size (R+C+S), we added a "bud count" (CO) category as a separate figure.

All prescribed burn methods, including design and execution, are under the field direction of Beaverhead National Forest. The environmental assessment work for the Canyon Creek - West quadrat has already been completed, and the burn took place in September of 1995. Vegetation and environmental post-burn data were collected at the Canyon Creek - West quadrat in 1996 and the post-burn photographs taken (Appendix C). The Badger Pass sites were not burned in the fall of 1996 as planned, so that we will have one additional pre-treatment year of data for most plots.

Both experimental design and burn treatment planning require that consideration be given to grazing by livestock and browsing by wildlife. Wildfires are beneficial to livestock and wildlife in similar regional settings and often attract elevated use (e.g., Gruell 1980). *Penstemon lemhiensis* is a palatable plant (Ramstetter 1983, Elzinga 1995), so the increased levels of browsing and grazing potentially negate the benefits of prescribed burning, and confound the analysis. We plan to exclude livestock grazing in the burn areas, and monitor the effects of browsing, as discussed separately for the three sites, below.

The Badger Pass Microwave Tower is in a grazing allotment. The transects are in a livestock exclosure, and the adjoining quadrat is outside the exclosure. Livestock use in the tower area is light or absent. The exclosure still admits wildlife, and wildlife browse has been high inside of it in some years (Shelly and Heidel 1995). The prescribed burn planned for the area is constrained by topography and proximity to the tower so that burn size cannot be extended much beyond the exclosure to disperse any increased browsing activity. The prescribed burn will extend into scattered aspen groves outside the exclosure which have high browse value - this does not substitute for or preclude browse within the exclosure and may actually enhance the levels of wildlife use in the area. The potential effects of browsing at this site are unmitigated.

The Badger Pass North site is also part of a livestock allotment. The prescribed burn will take place over a relatively large area, and may require use of electric fencing to keep livestock out. It will still admit big game. The anticipated increase in browsing levels will be dispersed though not excluded. We will continue to note all herbivory in the course of monitoring.

The Canyon Creek site is not grazed by livestock. It has limited forage value for big game, limited winter use, and alternate browse in the area.

The authorization for and feasability of burning was a year ahead of schedule for Canyon Creek compared to the other two sites, so it was burned in 1995. The prescribed burn treatment for the Canyon Creek West quadrat took place in September 1995 over an elongate area that ran perpendicular to the hill slope and spanned less than 5 acres. Post-burn monitoring data was collected here at the same time as the second year of pre-burn monitoring data elsewhere. Postburn ecodata plots and photo point documentation were made at Canyon Creek West, and are included with pre-burn datasets (Appendix B) and slide sets (Appendix C).

Data analysis for all plots (belt transects and quadrats) includes tracking of 54 summary statistics that reflect recruitment, mortality and fecundity, and the transitions between stages. Explanation is provided for each of the calculations (Appendix I) as they are derived from the raw data (Appendix E) that have been restructured in spreadsheet tables (Appendix F).

RESULTS

This report presents the first two years of monitoring data to evaluate the response of *Penstemon lemhiensis* to prescribed burn treatment. One of the six sample areas, Canyon Creek - West, was burned in 1995, and the other five sample areas have two years of pre-burn data. The first two years of data documented declines in most samples, ranging from 0-27% (Table 1).

Table 1. *Penstemon lemhiensis* established plants - 1995 and 1996

Sample set	**1995**	**1996**
Badger Pass Microwave - Belt Transect	41	30
Badger Pass Microwave - Quadrat	5	5
Badger Pass North - Belt Transect	6	6
Badger Pass North - Quadrat	23	17
Canyon Creek - East Quadrat	22	12
Canyon Creek - West Quadrat	57	**49***
TOTAL	154	119

* Data which is bold-faced represents the first year of monitoring after treatment

The raw data are detailed in Appendix E and indicate the life history stage, vegetative condition, and reproductive condition of each individual plant. The distinctions between flowering and nonflowering plants, and the addition of seedling data, is graphed for each data set in Appendix D to depict overall sample set demographics and trend.

Seedling decline was 87% between 1995 to 1996; only 1 of eight seedlings survived. Decline was 46% among the smallest established plants ("C" category; 7 out of 13 survived). Decline was highest for plants with the fewest rosettes; the mortality ranging from 12-50% for plants with only one rosette (R1).

All field data have been entered into Lotus files which contain prior demographic monitoring results. They are presented in Appendix F , and contain the same information as the raw data files only in spreadsheet form. These data spreadsheets have been used for calculating the 54 life history parameters and transitions (presented separately by year in Appendix G and H).

We will use a nonparametric method for comparing between years once post-burn data are available for all three sites. We will need to address autocorrelation, and incorporate climate data.

DISCUSSION

The only replicable *Penstemon lemhiensis* fire response studies available for management planning are represented in this study and a parallel Bitterroot National Forest study. Considering the range of habitat and site conditions of these studies, the results will have rangewide management application. It represents the evolution of sensitive species conservation and management response studies that advance the management policies of the Bureau of Land Management (Willoughby et al. 1992) and of the U.S. Forest Service (Reel et al. 1989).

The biggest potential limitation in the present study is in the small numbers making up the sample size. Without knowing the future trends and all statistical ramifications, we know that low population or subpopulation numbers are typical for this species and are important in species' viability.

In preliminary results, we note that postburn data in the Canyon Creek West quadrat present high levels of both mortality (i.e., the # of established plants dying) and recruitment (i.e., the total recruitment of established plant). Mortality exceeded recruitment, with 17 established plants dying and 8 new plants becoming established. It also had the highest number of seedlings (5). We note with concern that all flowers that were produced in the burned plot had aborted, a phenomenon not seen before in demographic monitoring. We will not interpret postburn results without looking at extended establishment, recruitment and fecundity patterns.

The seed germination study results are presented and discussed separately in Appendix G. They

The seed germination study results are presented and discussed separately in Appendix G. They are the basis for postulating that the effects of fire are least damaging to seed germination when the burns occur in the fall season.

Seedbank longevity remains an important unknown in the life history cycle. The USDA Bridger Plant Materials Center is germinating a set of *Penstemon lemhiensis* seeds collected from a site on French Creek by Pat Plantenberg in 1989 and stored under cool, dry conditions. A set of 400 seeds from this original sample set have been treated to four months cold stratification, and the viability of the 1989 seed material will be determined this winter (Winslow pers. comm.). Efforts to collect seed from the same site in 1996 were unsuccessful so that direct comparison cannot be made with fresh seed material. This may be pursued in the future. Results of the *Penstemon lemhiensis* viability test conducted by Bitterroot Native Growers for the Montana Department of Transporation are not available.

Macroplot data will be recollected in the year after burn treatment to document the response of the plant community at a coarse level. It will help interpret the community changes as well as the microclimate changes. Typical microhabitat values that have been measured in unburned habitats of southwestern Montana by Mueggler (1971). The latter study addressed air temperature, soil temperature, precipitation, relative humidity, soil moisture, soil nutrients, and solar radiation. There has not been similar local study of post-fire values for these parameters.

Our immediate work plan includes replication of monitoring in 1997. We will also try to reinstate the demographic monitoring established at two French Creek sites to gauge longevity. We will have preliminary results for evaluating the need for adding a seedbank longevity study component to the project. Finally, we will take tree borings at the study sites in the effort to to reconstruct on-site fire history.

This work is targeted to run through the 2000 field season. Annual updates will be produced which include updates of all raw data, tables, and graphs that are in this report. The final report will be produced by mutual agreement at the culmination of annual monitoring.

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Appendix A. Permanent plot locations - maps and descriptions

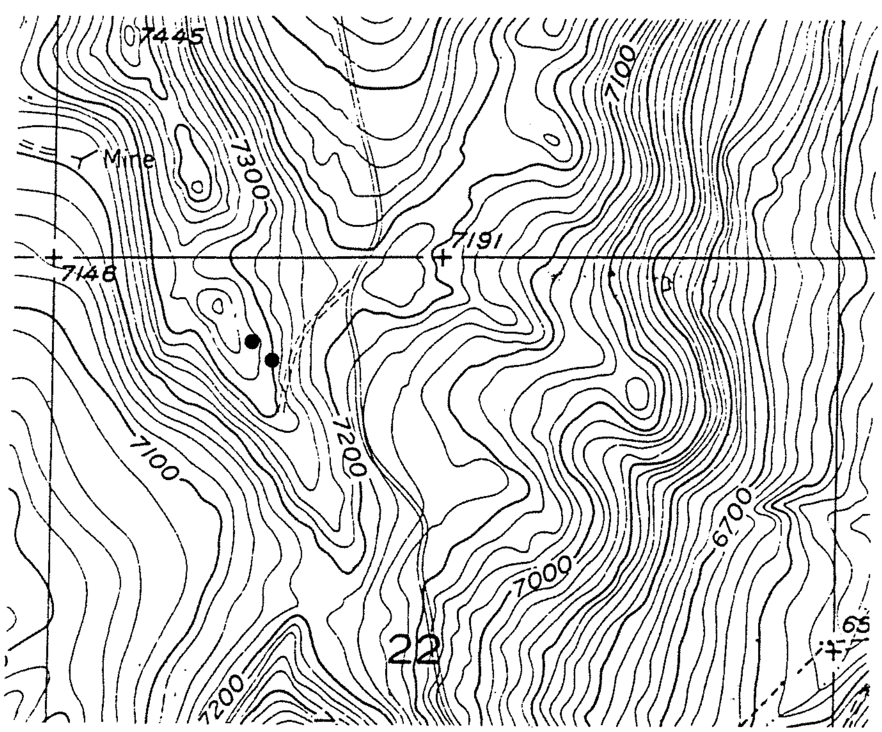
Location, layout and description of all pre-existing belt transects and new quadrats are detailed on the following pages accompanied by maps. Photographic and ecodata sampling records for all new plots follows in Appendix B and C, respectively.

Badger Pass Microwave Tower Site - EO#5
(Also referred to as Exclosure site)
Belt transects established in 1991, quadrat established in 1995

Location: Bannack Quad (4511228)
T.7S R.11W. Sec. 22, N 1/2 of NW 1/4
Accessible via maintained gravel road to microwave tower; located northwest of the microwave tower parking lot. Habitat: Deep-soil Douglas-fir Openings (Type 3) in a foothills setting (7260'). (Note: This is located less than 3 miles ssw. of the Badger Pass North site but in a different setting.)

Belt Transects (three short discontinuous transects; whose results are tallied together)
Transect 1: 11 meters long; in southeast corner
Transect 2: 10 meters long; look for tag numbers 41-43
Transect 3: 5 meters long; look for tag numbers 22-30

Quadrat: The Quadrat is located outside the irregularly-shaped exclosure where the exclosure pinchs inward along its western upper margin.
Slope: 26 Aspect: 101



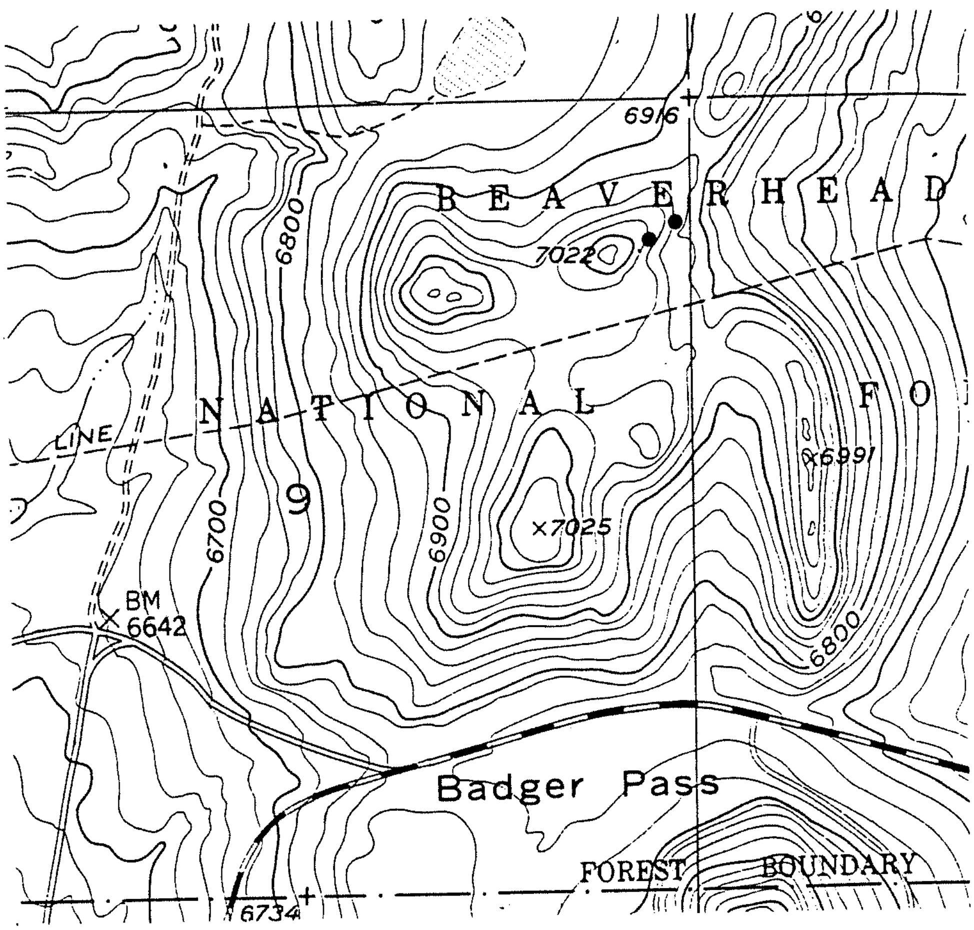
Badger Pass North - EO#19
Transect established in 1989, quadrat established in 1995

Location: Bannack Quad (4511228)
T. 7S R/11W Sec. 9 SE1/4 of NE1/4 of NE1/4.

Accessible via FS Rd. 7467 and 1/2 mile hike eastward; or two-track road from Hwy. 278 crossing BLM land in Sec. 10. Habitat: Deep-soil Rangeland (Type 1) in a foothills setting (6980 ft)

Belt Transect: 50 meters long; read from west to east.
Transect line bearing: 31 degrees
Slope: 18 degrees Aspect: 106 degrees

Quadrat: The Quadrat is located southwest of and slightly higher than the belt transect at a similar mid- to lower-slope position.
Slope: 34 Aspect: 80

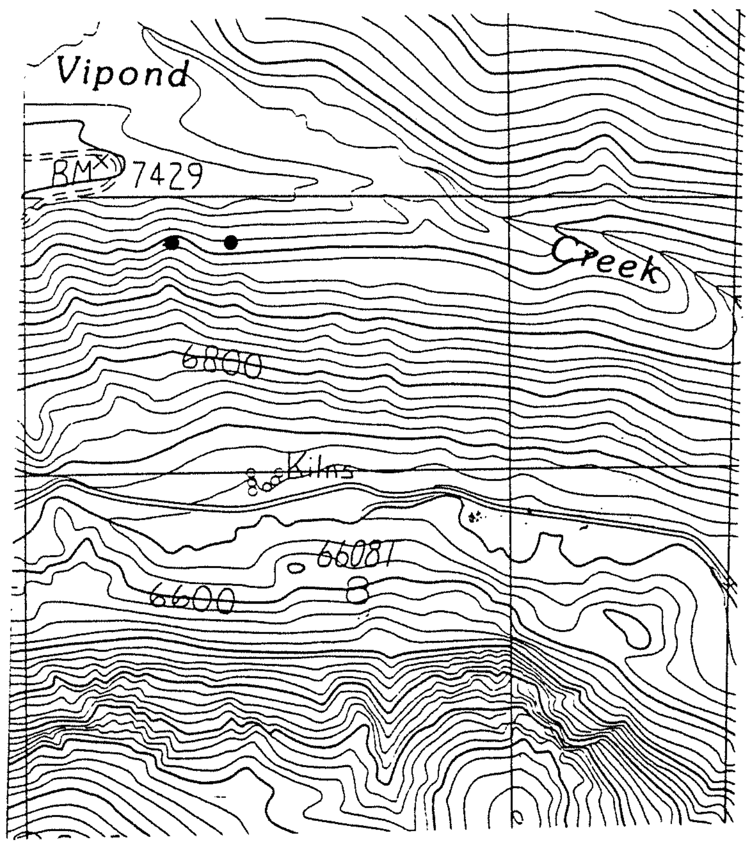


Canyon Creek - EO#38
(Also variously referred to as the Kiln site or Vipond Park site in other studies)
Quadrats established in 1995

Location: Cattle Gulch Quad (4511267)
T.2S R.10W Sec. 8 NE 1/4 of NW 1/4
Accessible via FS Rd. 187 and hike 1/10 mile eastward from the ridge crest.
Habitat: Deep-soil Douglas-fir Openings (Type 3) in a montane valley setting (7320 ft)

East Quadrat: The Quadrat is located almost below the historic log ramp structure at an upper-slope position.
Slope: 51 Aspect: 129

West Quadrat: The Quadrat is located beyond the first draw app. 1/10 mile southeast of the point where the road crosses the crest of the ridge at an upper slope position.
Slope: 50 Aspect: 148



Appendix B. Quadrat ecodata records

BLM Badger Pass
Microwave Quadrat

Form GF: General Field Data (Chapter 3B-1) - 6/92

Key ID: F1-7:	Ag	R/S	N F	R D	Yr	Ex	Plt	F8 Name	F9 Mo	F10 Day
	FS	01	02	01	95	DS	004	SVOBODA	08	18

SAMPLE SYSTEM DATA

F11-30: Sample Forms | GF | LL | PC | | | | | | | | F31-Unit | E | F32-PRL | 37 | F33-PW | 000 |

F34 Permanent Plot ID	F35 PRI	F36 Comparison Plot ID
ES01020195DS004	01	

Potential Vegetation F37-42:	Form	PVC	Ind Spp 1	Ind Spp 2	Ind Spp 3	Site Phase
	SU	MUST 80	ARTTSV	FESIDA	AGRSPI	

EXISTING VEGETATION CLASSIFICATION

EV Strata: F43-46:	LF	LSC	DSC	CC
	C	PT	LS	L

Veg Layers: F47-52:	UL Dom Spp1	UL Dom Spp2	ML Dom Spp1	ML Dom Spp2	LL Dom Spp1	LL Dom Spp2
	PSEMEN	PINFLE	ARTISV	LUPSER	FESIDA	ARECON

SITE DATA

F53 SpFea | RR | F54-56 Landform | UM | SC | UD | F57-59 PMat | ME | QU | | F60-61 Pos | RI | NW | F62-VerPS | R | F63*-HorPS | S |

F64-Elevation | | F65-Aspect | 101 | F66-Slope | 26 | Horizon: F67-69*: | E 001 | S 002 | W 021 |

F70-EroStat | ST | F71-EroType | SE | F72-79: GCov BS 01 + Gr 03 + Ro 20 + LD 50 + Wo 05 + ML 01 + BV 20 + Wa 00 | F80 FLC | 05 | F81 FD | 1.5 | F82 DLDepth | 0.4 |

F83-Dead Wood Cover | 01 | F84-Down Log Dia | 000 | F85-Dom. Layer Ht. | 15 |

VEGETATION DATA

Live Tree: F86-89:	BAF	BAN	BA	DBH	Height	Age	Dead Tree: F90-92:	BAF	BAN	BA	DBH	Height
	10	1	10	3	15	45		00	00	000	000	000

TreeCover: F93-99:	Tot	Seed	Sap	Pole	Med	Large	VLarg	ShrubCover: F100-103:	Tot	Low	Mid	Tal	HerbCov: F104-107:	Gram	Forb	Fern	Moss
	30	03	03	20	10				10	10				40	20	00	01

Dry Weight Production (Fields 108-113)*

	GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght
F108-Tree				F109-Shrub				F110-Gram			
F111-Forb				F112-Fern				F113-Moss			

DISTURBANCE DATA

F114-116-Ground Cover Dist	M	F	A	F117-122-AnimalEvid	1	2	3	4	5	6	F123* Size Class
	N	N	N								

BLM Badger Pass
Microwave Quadrat

Form PC: Plant Composition Data (Chapter 3B-3) - 7/92

Key ID: F1-7:	Ag	R/S	NF	RD	Yr	Ex	Plt	F-8-PlantIDL
	FS	01	03	01	95	DS	004	00

	F9 LF	F10 Plant Name	F11 CC	F12 MHt	F13 Size Class 1	2	3	4	5	6	F14 * SFM	F15 * Ph	F16 * Ut	F17 * Op	Notes
1	T	PSEMEN	30	L5	03	03	20	10			LY	3			
2	T	PINFLE	03	L3				03			LM	3			
3	S	ARTTSV	10	2	10						LY	3			
4	F	LUPARG	10	1								3			
5	F	CASPAL	01	0								3			
6	F	TRIDUB	01	1								3			~~Artemesia tri~~
7	S	ARITRE	03	1	03						LY	3			check synon
8	F	ARECON	10	0								2			
9	F	ALLCER	01	1								3			
10	F	LITRMD	01	1								3			
11	F	LOMTRI	01	1								3			
12	F	ERIUMB	05	0								3			
13	F	ACHMEL	01	0								2			Red
14	F	CASPUL	01	0								3			
15	F	SOLSIL	01	1								2			solidago
16	F	ERI	01	0								3			erigeron
17	F	PENLEM	01	1								3			
18		COL	01	0								3			colensia
19		CREATI	01	1								3			? on Maloc
20		AGRSPI	10	1								3			
21	G	CARROS	03	0								3			
22	G	FESIDA	30	1								3			
23	G	STICOM	01	1								3			
24	F	ASTSTE	01	1								3			
25	F	ANTCOR	10												
26		SEL	03	0											seliginell
27	F	AGOGLU	01	0											agoseris
28	F	CALNUT	01	1											
29	F	ZYGPAN	01	1											
30	F														
31	S	CHRVIS	01	1	01										
32	F	LOMMAC	01	1											
33	F	GEUTRE	01	0											
34	F	AST	01	1											bitteroot
35	F	LUCRED	01	0											
36															
37															
38															
39															
40															

*Optional Fields

USFS Badger Pass North Quadrat

Form GF: General Field Data (Chapter 3B-1) - 6/92

Key ID: F1-7:	Ag	R/S	N F	R D	Y r	E x	P l t	F8 Name	F9 Mo	F10 Day
	FS	01	02	01	95	DS	005	SVOBODA	08	18

SAMPLE SYSTEM DATA

F11-30: Sample Forms | GF | LL | PC | | F31-Unit | E | F32-PRL | 37 | F33-PW | 000 |

F34 Permanent Plot ID	F35 PRI	F36 Comparison Plot ID
FS01020195DS005	01	

Potential Vegetation F37-42:	Form	PVC	Ind Spp 1	Ind Spp 2	Ind Spp 3	Site Phase
	SU	MUST | 80	ARTTSV	FESIDA	JUNCOM	

EXISTING VEGETATION CLASSIFICATION

EV Strata: F43-46: | LF | LSC | DSC | CC |

Veg Layers: F47-52:	UL Dom Spp1	UL Dom Spp2	ML Dom Spp1	ML Dom Spp2	LL Dom Spp1	LL Dom Spp2
	PINFLE	PSEMEN	ARTTSV	LUPSER	FESIDA	ARECON

SITE DATA

F53 SpFea: N | F54-56 Landform: 4M \| SC \| UD | F57-59 PMat: ME \| 94 \| AR | F60-61 Pos: MS \| LS | F62-VerPS | S | F63*-HorPS | S |

F64-Elevation | | F65-Aspect | 80 | F66-Slope | 34 | F67-69*: Horizon: E 002 | S 006 | W 007 |

F70-EroStat | ST | F71-EroType | SE | F72-79: GCov BS 20 + Gr 03 + Ro 20 + LD 40 + Wo 03 + ML 01 + BV 10 + Wa 00 | F80 FLC 06 | F81 FD 1.5 | F82 DLDepth 0.3 |

F83-Dead Wood Cover | 00 | F84-Down Log Dia | 000 | F85-Dom. Layer Ht. | 2 |

VEGETATION DATA

Live Tree: F86-89:	BAF	BAN	BA	DBH	Height	Age
	10	0	1		13	45

Dead Tree: F90-92:	BAF	BAN	BA	DBH	Height
	00	00	000	000	000

TreeCover: F93-99:	Tot	Seed	Sap	Pole	Med	Large	VLarg
	03	00	00	03			

ShrubCover: F100-103:	Tot	Low	Mid	Tal
	10	10		

HerbCov: F104-107:	Gram	Forb	Fern	Moss
	30	20	00	01

Dry Weight Production (Fields 108-113)*

	GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght
F108-Tree				F109-Shrub				F110-Gram			
F111-Forb				F112-Fern				F113-Moss			

DISTURBANCE DATA

F114-116-Ground Cover Dist | M: N | F/A: N | L | F117-122-AnimalEvid | 1: CA | 2: | 3: | 4: | 5: | 6: | F123* Size Class | |

USFS Badger Pass
North Quadrat

Form PC: Plant Composition Data (Chapter 3B-3) - 7/92

Key ID: F1-7:	Ag	R/S	NF	RD	Yr	Ex	Plt	F-8-PlantIDL
	FS	01	02	01	95	DS	005	001

	F9 LF	F10 Plant Name	F11 CC	F12 MHt	F13 Size Class 1	2	3	4	5	6	F14* SFM	F15* Ph	F16* Ut	F17* Op	Notes
1	T	PINFLE	01	14			01				LY	3	0		
2	T	PSEMEN	01	10			01				LY	3	0		
3	S	ARTTSV	10	2	10						LY	3	0		
4	S	JUNCOM	03	1	03						LY	1	0		
5	S	RIBSER	01	3		01					LY	1	0		
6	G	FESIDA	30	0								3	40		
7	G	AGRSPI	10	1								3	40		
8	G	CARROS	10	0								3	03		check sync
9	F	BALSAG	01	1								3	01		
10	F	SOLMIS	01	0								1	01		
11	F	POTLAN	01	0								3	01		
12	F	ANICOR	03	0								3	00		
13	F	CASPAL	01	0								3	0		
14	F	ACHMIL	01	0								3	0		
15	F	EREUMB	10	0								3	0		
16	F	HYECYN	03	0								2	0		
17	F	ARECON	10	0								3	0		
18		LUPSER	10	1								3	L0		
19		ANTROS	03	0								3	0		
20		ALLSER	01	0								3	0		
21	F	LITRUD	01	1								1	0		
22	F	PENLEM	01	0								3	03		
23	F	ZYGPAN	01	1								3	00		
24	F	ARAHOL	01	0								1	00		
25	F	ERI		0											
26	F	POTGLA	01	1											
27	F	ASTSTE	01	0											
28	F	POLDOU	01	0											
29															
30															
31															
32															
33															
34															
35															
36															
37															
38															
39															
40															

*Optional Fields

USFS Canyon Creek East Quadrat

Form GF: General Field Data (Chapter 3B-1) - 6/92

Key ID: F1-7:	Ag	R/S	N F	R D	Y r	E x	P l t	F8	Name	F9	Mo	F10	Day
	F S	0 1	0 2	0 2	9 5	D S	0 0 3		KELLEY SVOBODA		0 8		1 7

SAMPLE SYSTEM DATA

F11-30: Sample Forms | GF | PC | | F31-Unit | E | F32-PRL | 3 7 | F33-PW | 0 0 0 |

F34	Permanent Plot ID	F35	PRI	F36	Comparison Plot ID
	FS0102029 5DS002		01		

Potential Vegetation F37-42:	Form	PVC		Ind Spp 1	Ind Spp 2	Ind Spp 3	Site Phase
	SU	MUST	80	ARTISV	FESIDA	AGRSPI	

EXISTING VEGETATION CLASSIFICATION

EV Strata: F43-46: | LF | LSC | DSC | CC |

Veg Layers: F47-52:	UL Dom Spp1	UL Dom Spp2	ML Dom Spp1	ML Dom Spp2	LL Dom Spp1	LL Dom Spp2
	PSEMEN		ARTISV		FESIDA	AGRSPI

SITE DATA

F53 SpFea: UW | F54-56 Landform: GM / TW / UD | F57-59 PMat: IG / GR / GT | F60-61 Pos: MS / US | F62-VerPS | D | F63*-HorPS | D |

F64-Elevation | _ _ _ _ _ | F65-Aspect | 1 3 9 | F66-Slope | 0 5 1 | Horizon: F67-69*: E 0 1 1 | S 0 1 0 | W 0 0 9 |

F70-EroStat | ST | F71-EroType | SE | F72-79: GCov BS 30 + Gr 10 + Ro 10 + LD 40 + Wo 10 + ML 01 + BV 10 + Wa 00 | F80 FLC 05 | F81 FD 1.5 | F82 DLDepth .2 |

F83-Dead Wood Cover | 0 0 | F84-Down Log Dia | 0 0 0 | F85-Dom. Layer Ht. | 1 |

VEGETATION DATA

Live Tree: F86-89:	BAF	BAN	BA	DBH	Height	Age	Dead Tree: F90-92:	BAF	BAN	BA	DBH	Height
	10	01	010	007	10	45		00	00	000	000	000

TreeCover: F93-99:	Tot	Seed	Sap	Pole	Med	Large	VLarg	ShrubCover: F100-103:	Tot	Low	Mid	Tal	HerbCov: F104-107:	Gram	Forb	Fern	Moss
	10	03		03	03				10	10				30	10		01

Dry Weight Production (Fields 108-113)*

	GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght		GrnWt	DWF	Dry Wght
F108-Tree				F109-Shrub				F110-Gram			
F111-Forb				F112-Fern				F113-Moss			

DISTURBANCE DATA

F114-116-Ground Cover Dist	M	F	A	F117-122-AnimalEvid	1	2	3	4	5	6	F123*	Size Class
	L	N	L		DE							

USFS Canyon Creek
East Quadrat

Form PC: Plant Composition Data (Chapter 3B-3) - 7/92

Key ID: F1-7:	Ag	R/S	NF	RD	Yr	Ex	Plt	F-8-PlantIDL
	FS	01	02	02	95	DS	003	00

	F9 LF	F10 Plant Name	F11 CC	F12 MHt	F13 Size Class 1	2	3	4	5	6	F14 * SFM	F15 * Ph	F16 * Ut	F17 * Op	Notes
1	T	PSEMEN	L0	10	03		03	0L			LY	3	00		
2	S	ABLISV	10	2	10						LM	3			
3	G	FESIDA	10	0								3			
4	G	AGRSPI	30	1								3			
5	G	POACOM	01	1								3			TRISETUM
6	G	CAREIL	01	0								3			
7	F	LUPSER	05	1								3	01		
8	F	ARAHOB	0L	0								3	00		Arabis
9	F	LITRUD	01	1								3			
10	F	CASPAL	03	1								3			
11	F	COLLIN	01	0								4			Collomia
12	F	CEDLAN	0L	0								2			
13	S	ARIFRI	0L	1	0L						LY	3			
14	F	TAROFF	01	0								3 4			
15	F	DELBIC	01	0											
16	F	ARAGLA	0L	1								3			Arabis
17	F	ARECON	01	0								3			
18	F	PENLEM	01	1								3			
19		ACHMIL	01	0								2			
20	F	PLHAS	01	0								2			
21	F	GILTEN	01	0								3			
22	F	ASTSTE	01	0								3			
23	F	ASTMIS	01	0								3			
24	F	TRADUB	01	1								3			
25	S	CHRVIS	01	1	01						LY	3			
26	G	POAJUN	01	1								3			
27	F	COLPAR	01	1								3			
28	F	CREMOD	01	1								3			
29	F	ERIUMB	01	0								3			
30	F	BALSAG	01	1								3			
31	F	ANTCOR	01	0								3			Antennari
32															
33	F	ALLSER	01	1								3			Tufted Ca
34	F	CARROS	01	0								3			check sp
35	F	ANTROS	01	0								3			
36	F	SOLSIL	0L	1								3			Solidago
37	F	PENARI	0L	0								3			
38	F	POLDOU	01	0								3			
39	F	PHLLON	01	0								4			
40		CEDBOR	01	0								2			
	F	SILPAR	01	1								3			

*Optional Fields

USFS Canyon Creek
West Quadrat

Form GF: General Field Data (Chapter 3B-1) - 6/92

* Look up HT

Key ID: F1-7:	Ag	R/S	N F	R D	Y r	E x	P l t	F8 Name	F9 Mo	F10 Day
	FS	01	02	02	95	DS	002	KELLEY SVOBODA	08	17

SAMPLE SYSTEM DATA

F11-30: Sample Forms | GE | PC | LL | | F31-Unit | E | F32-PRL | 37 | F33-PW | 000 |

F34 Permanent Plot ID	F35 PRI	F36 Comparison Plot ID
ES0102095DS001	01	

Potential Vegetation F37-42:	Form	PVC	Ind Spp 1	Ind Spp 2	Ind Spp 3	Site Phase
	SU	MUST 80	ARTTSV	FESIDA	AGRSPI	

EXISTING VEGETATION CLASSIFICATION

EV Strata: F43-46: | LF | LSC | DSC | CC |

Veg Layers: F47-52:	UL Dom Spp1	UL Dom Spp2	ML Dom Spp1	ML Dom Spp2	LL Dom Spp1	LL Dom Spp2
	PINFLE	PSEMEN	ARTTSV	LUPSER	FESIDA	CASPAL

SITE DATA

F53 SpFea: UW | F54-56 Landform: GM, TW, UP | F57-59 PMat: IG, GR, GT | F60-61 Pos: MS, US | F62-VerPS: D | F63*-HorPS: D

F64-Elevation | | F65-Aspect | 148 | F66-Slope | 50 | Horizon: F67-69*: E 004 | S 009 | W 021

F70-EroStat | ST | F71-EroType | SE | F72-79: GCov BS 20 + Gr 10 + Ro 10 + LD 40 + Wo 3 + ML 0 + BV L + Wa 1 000 | F80 FLC 05 | F81 FD 1.2 | F82 DLDepth .2

F83-Dead Wood Cover | 00 | F84-Down Log Dia | 000 | F85-Dom. Layer Ht. | 001 |

VEGETATION DATA

Live Tree: F86-89:	BAF	BAN	BA	DBH	Height	Age
	10	00	005	003	007	20

Dead Tree: F90-92:	BAF	BAN	BA	DBH	Height
	00	00	000	000	000

TreeCover: F93-99:	Tot	Seed	Sap	Pole	Med	Large	VLarg
	10	03	03	03	00	00	00

ShrubCover: F100-103:	Tot	Low	Mid	Tal
	10	10	00	00

HerbCov: F104-107:	Gram	Forb	Fern	Moss
	30	20	00	01

Dry Weight Production (Fields 108-113)*

	GrnWt	DWF	Dry Wght
F108-Tree			
F109-Shrub			
F110-Gram			
F111-Forb			
F112-Fern			
F113-Moss			

DISTURBANCE DATA

F114-116-Ground Cover Dist | M N | F N | A N | F117-122-AnimalEvid | 1 | 2 | 3 | 4 | 5 | 6 | F123* Size Class | |

USFS Canyon Creek

West Quadrat

Form PC: Plant Composition Data (Chapter 3B-3) - 7/92

Key ID: F1-7:	Ag	R/S	NF	RD	Yr	Ex	Plt	F-8-PlantIDL
	FS	01	02	02	95	DS	002	00

	F9 LF	F10 Plant Name	F11 CC	F12 MHt	F13 Size Class 1	2	3	4	5	6	F14 * SFM	F15 * Ph	F16 * Ut	F17 * Op	Notes
1	T	PINFLE	03	16			03				LY	2	00		
2	T	PSEMEN	03	6	05						LY	2			
3	S	ARTTSV	10	1	10						LM	3			
4	S	CHRVIS	01	1	01						LY	2			
5	S	ARIERI	03	1	03						LY	3			
6	F	LETRUD	01	1								1			
7	S	RIBSER	01	2		01					LD	4			
8	G	FESIDA	20	1								3			
9	G	AGRCAN	20	1								3			
10	G	ELYCIN	01	2								3			
11	F	LUPSER	10	1								3			
12	F	BALSAG	03	1								1			
13	F	CEDLAN	01	0								3			
14	F	ACHMIL	01	0								2			
15	F	ASTMIS	01	0								3			
16	F	CASPAL	05	1								3			
17	F	ARAHOB	01	0								3			
18	F	CHRVIL	01	1								3			
19	F	PHAHAS	01	0								1			
20	F	ERIUMB	03	0								3			
21	F	ANTCOR	01	0								3			~~Potentilla~~
22	F	CREMOD	03	1								3			
23	F	CEDBOR	01	0								3			
24	S	TETCAN	01	1	01						LY	2			
25	F	ARECON	01	0								3			
26	F	ALLSER	01	0								3			
27	S	AREDRE	01	0											
28	F	ERICOM	01	0								3			
29	F	ASTSIE	01	0								3			
30	F	COLPAR	01	1								3			
31	F	GILDIE	01	0								3			
32	F	SOLMIS	01	1								2			
33	F	TAROFF	01	0								3			
34	F	PENLEM	01	1								3	01		
35	F	TRADUB		1								3	00		
36	F	LOMTRI	01	1								3			
37	F	COLLIN	05	0								3			
38	F	DELBIC	01	0								4			
39	F	GILIEN	01	0								4			
40	F	POTLAN	01	0											
	F	PHLLON	01	0											
	F	ERISPI	01	0											

*Optional Fields

Appendix C. Quadrat photo records
(Slide duplicates of the following entire set have been submitted to both agencies, with the originals kept on file.)

PENLEM
Badger Pass N-
lower quadrat border

95DS005

18 Aug 95 BH

Badger Pass N -side
quadrat border

95DS005

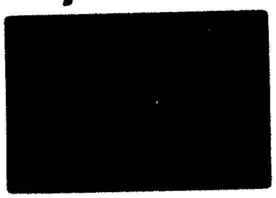
18 Aug 95 BH

Badger Pass N - diagonal

95DS005

18 Aug 95 BH

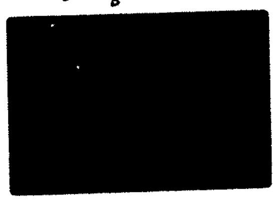
PENLEM
Canyon Cr. E - lower
quadrat border



95DS003

17 Aug 95 BH

PENLEM
Canyon Cr. E-side
quadrat border



95DS003

17 Aug 95 BH

PENLEM
Canyon Cr E - diagonal

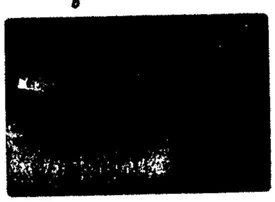
95DS003

17 Aug 95 BH

PENLEM
Canyon Cr E - outsi

17 Aug 95 B

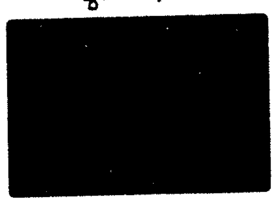
PENLEM
Canyon Cr W - lower
quadrat border



95DS002

17 Aug 95 BH

PENLEM
Canyon Cr. W- side
quadrat border



95DS002

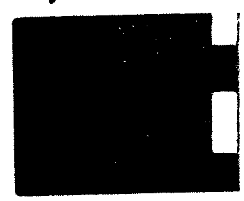
17 Aug 95 BH

PENLEM
Canyon Cr W - diagonal

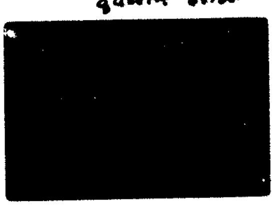
95DS002

17 Aug 95 BH

PENLEM
Canyon Cr. W - overv



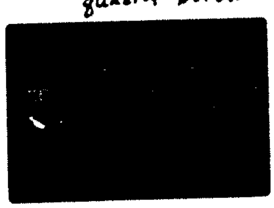
PENLEM
BP Microwave - lower
quadrat border



95DS004

18 Aug 95 BH

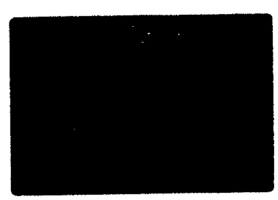
PENLEM
BP Microwave -side
quadrat border



95DS004

18 Aug 95 BH

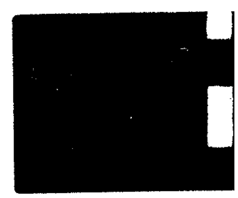
PENLEM
BP Microwave - diagonal



95DS004

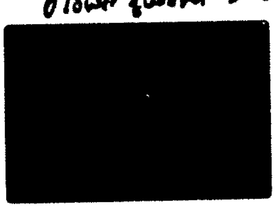
18 Aug 95 BH

PENLEM
BP Microwave Exc



18 Aug 95

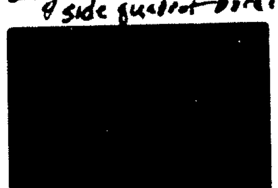
PENLEM - post-fire
Canyon Creek West
lower quadrat border



96DS

Horizontal
17 Aug 1996

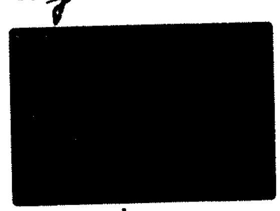
PENLEM Post-fire
Canyon Creek West
side quadrat border



96DS

17 Aug 1996

PENLEM Post-fire
Canyon Cr. West



96DS

Diagonal
17 Aug 1996

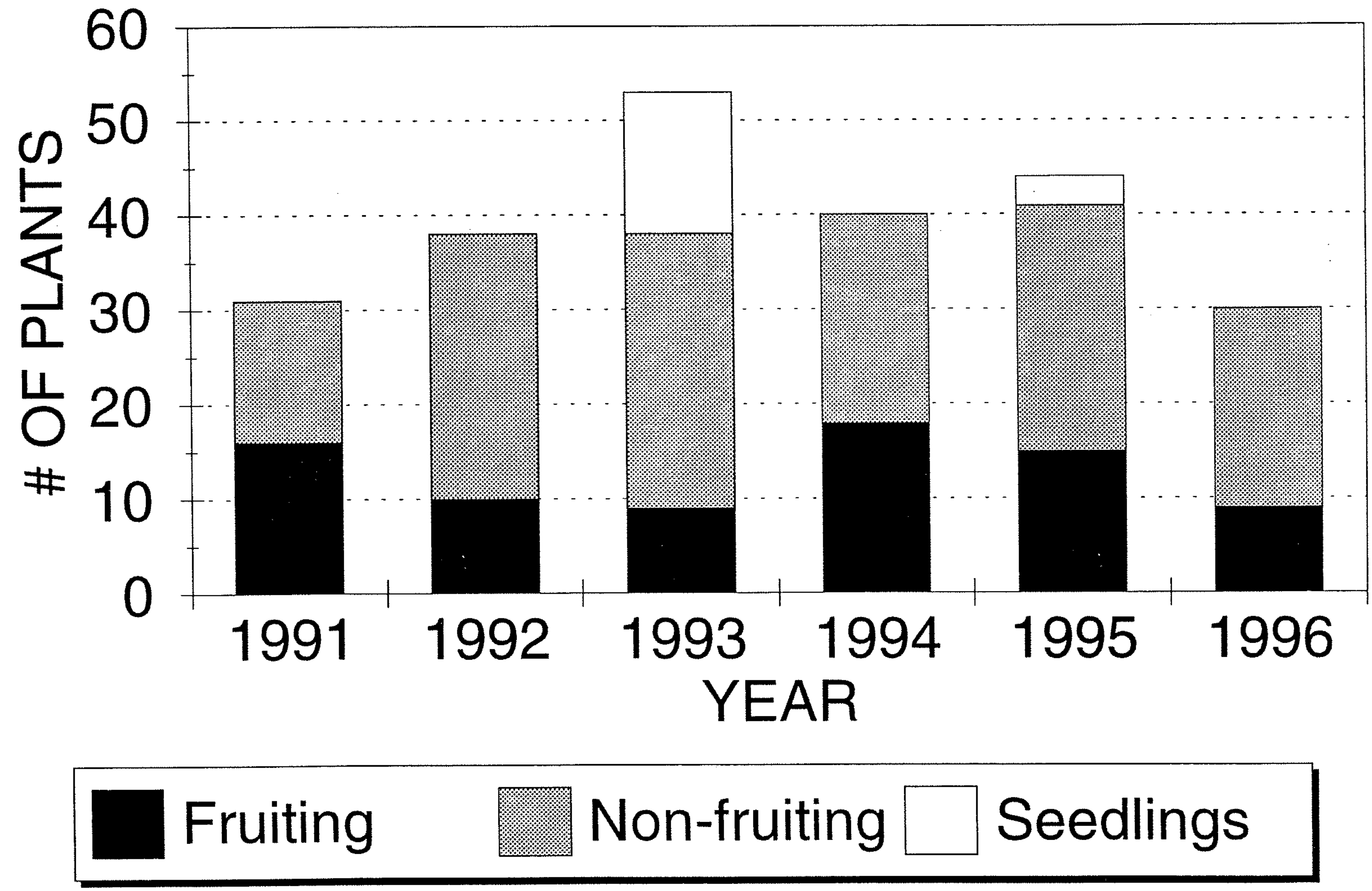
PENLEM
Canyon Creek E

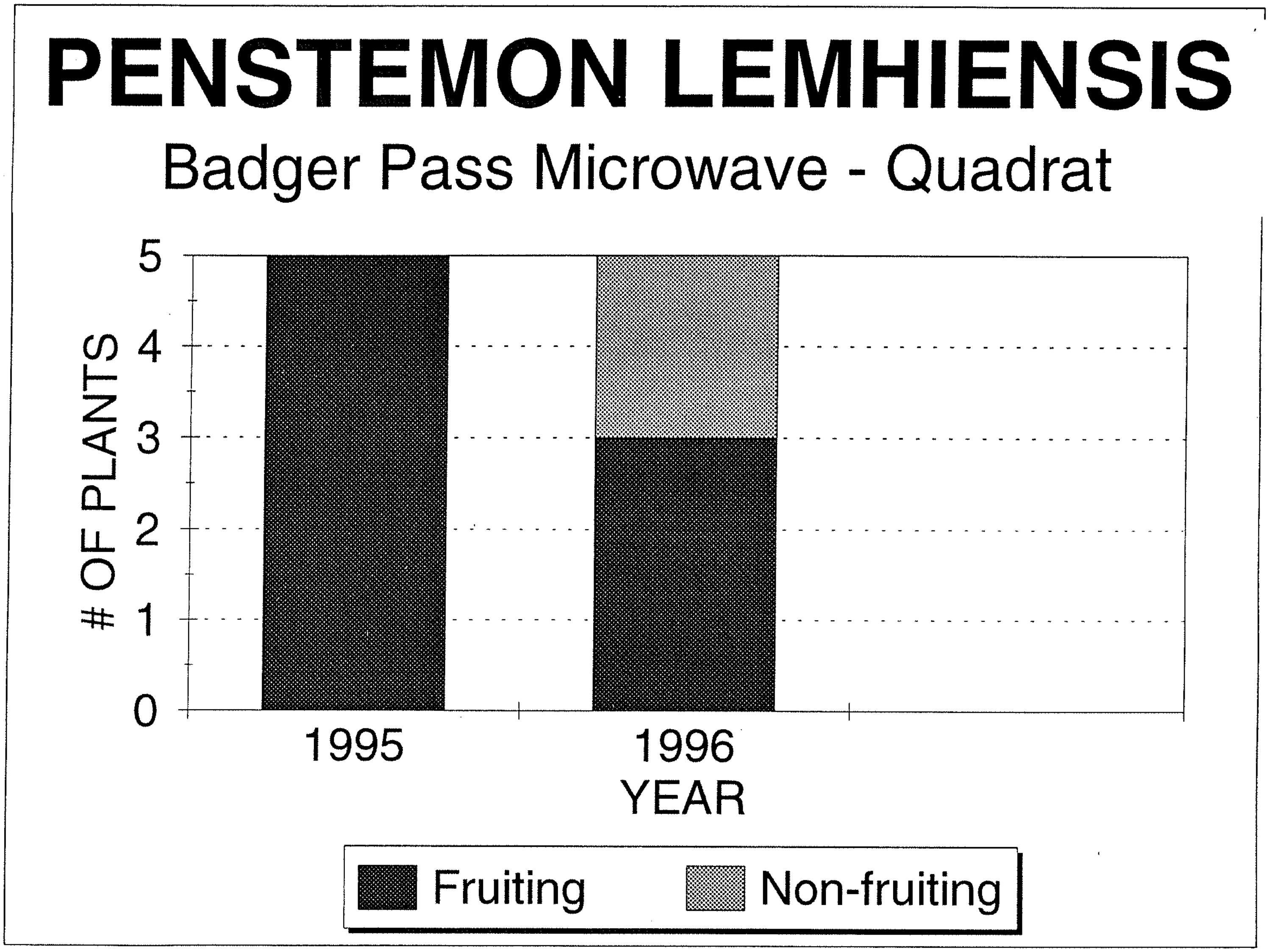
17 Aug 1996

Appendix D. *Penstemon lemhiensis* trend data graphs for six sample sets in fire response monitoring, 1995-1996

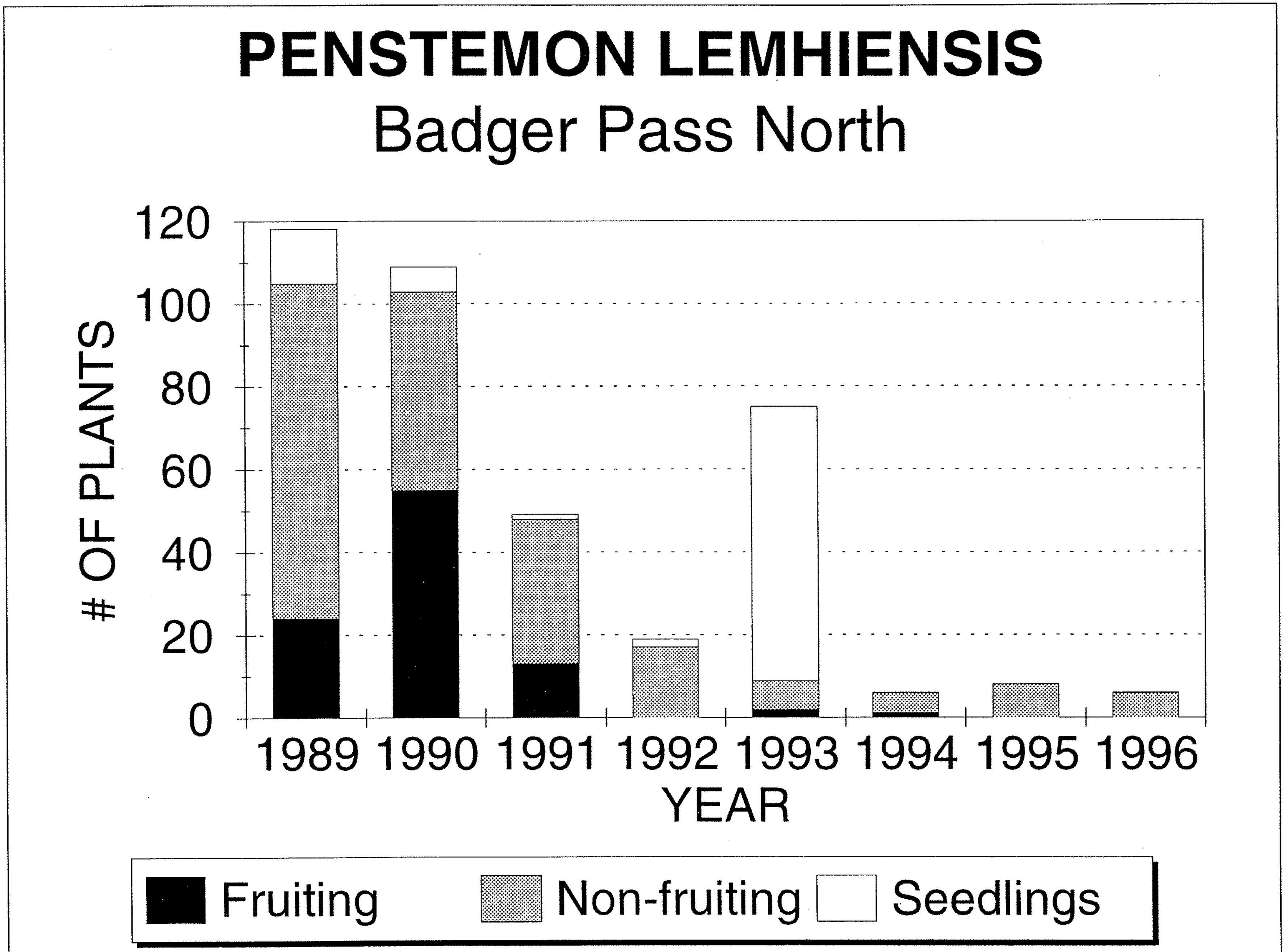
PENSTEMON LEMHIENSIS

Badger Pass Microwave Exclosure

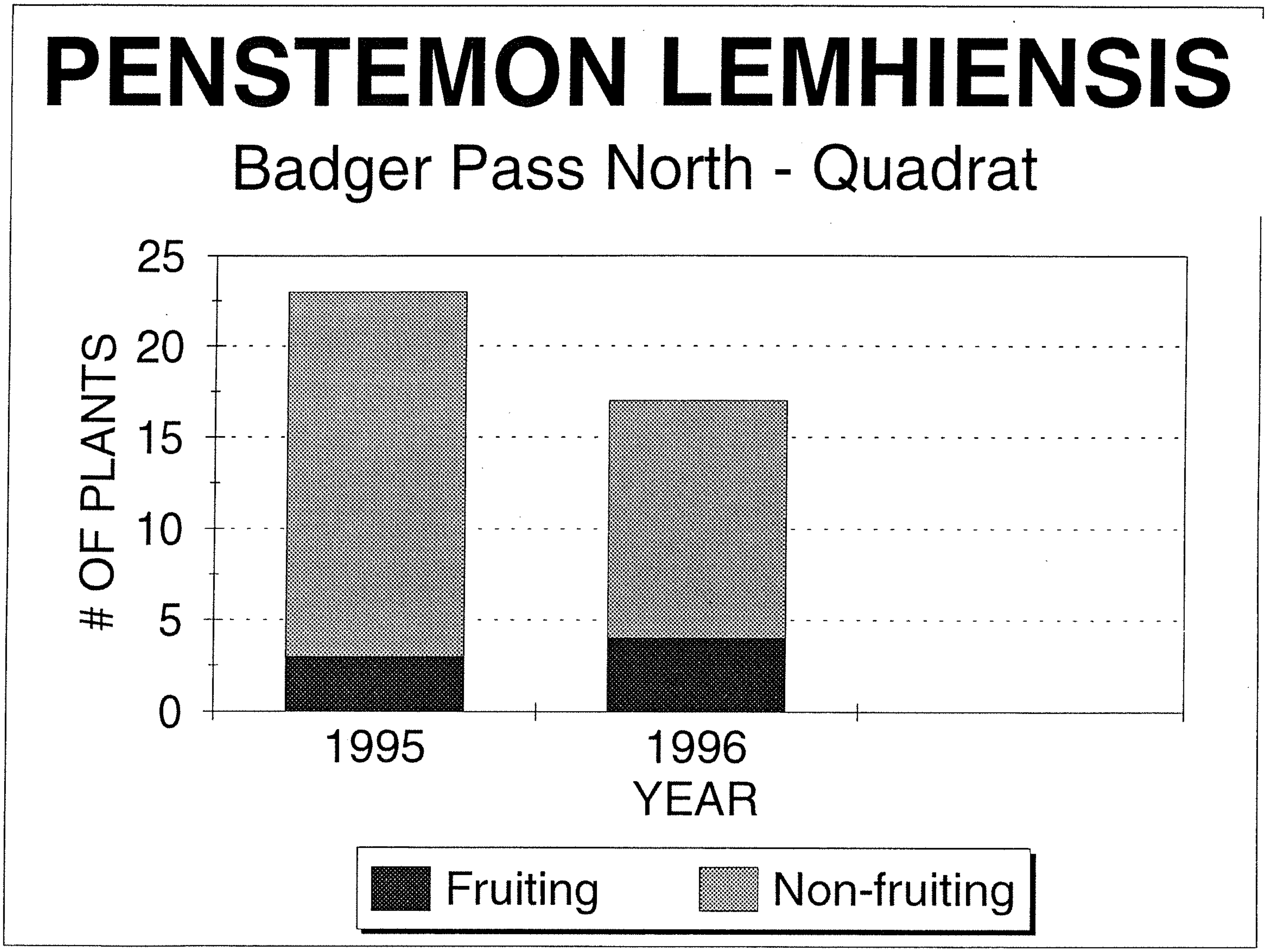




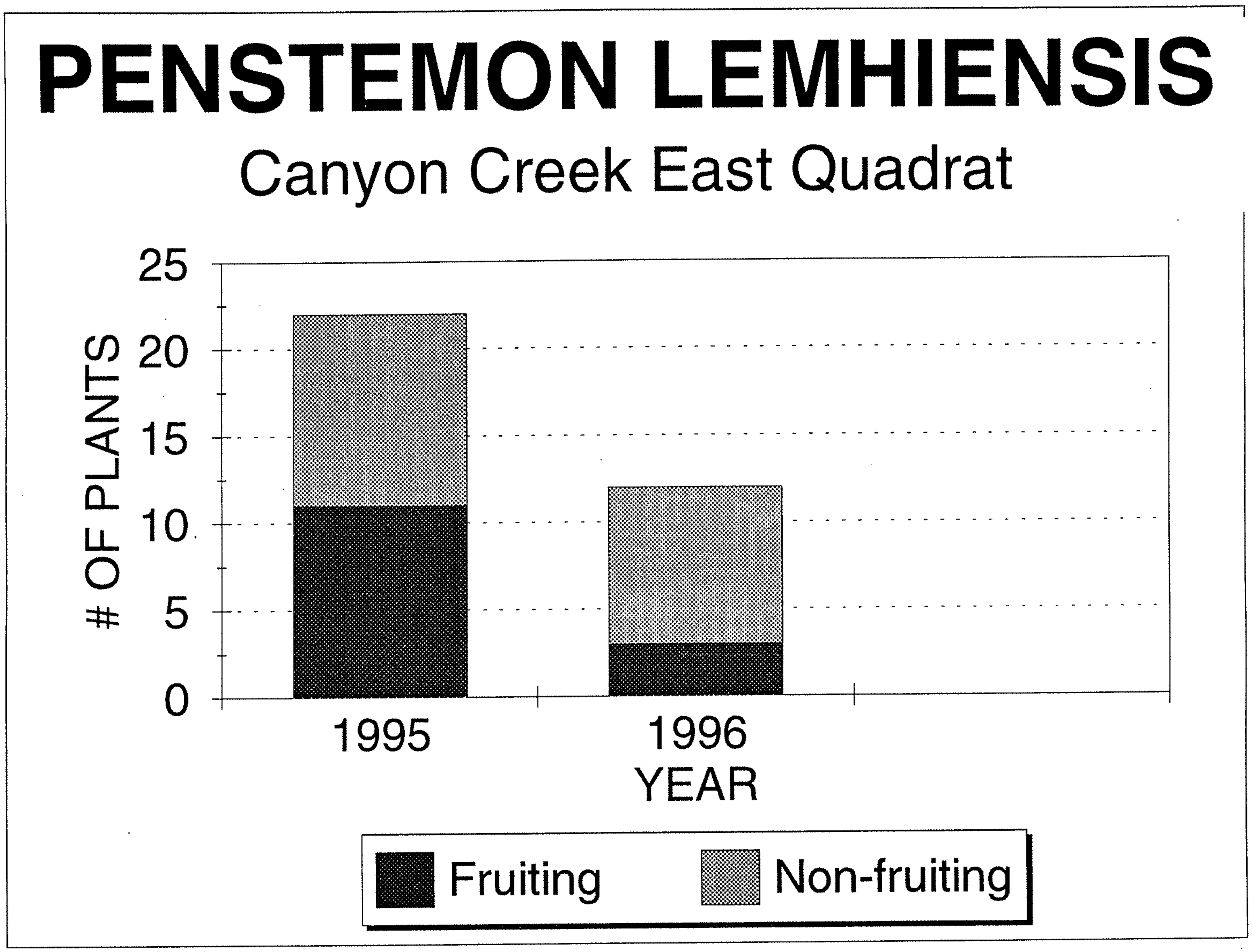
PENSTEMON LEMHIENSIS
Badger Pass Microwave - Quadrat
OF PLANTS
0
1
2
3
4
5
1995
1996
YEAR
Fruiting
Non-fruiting

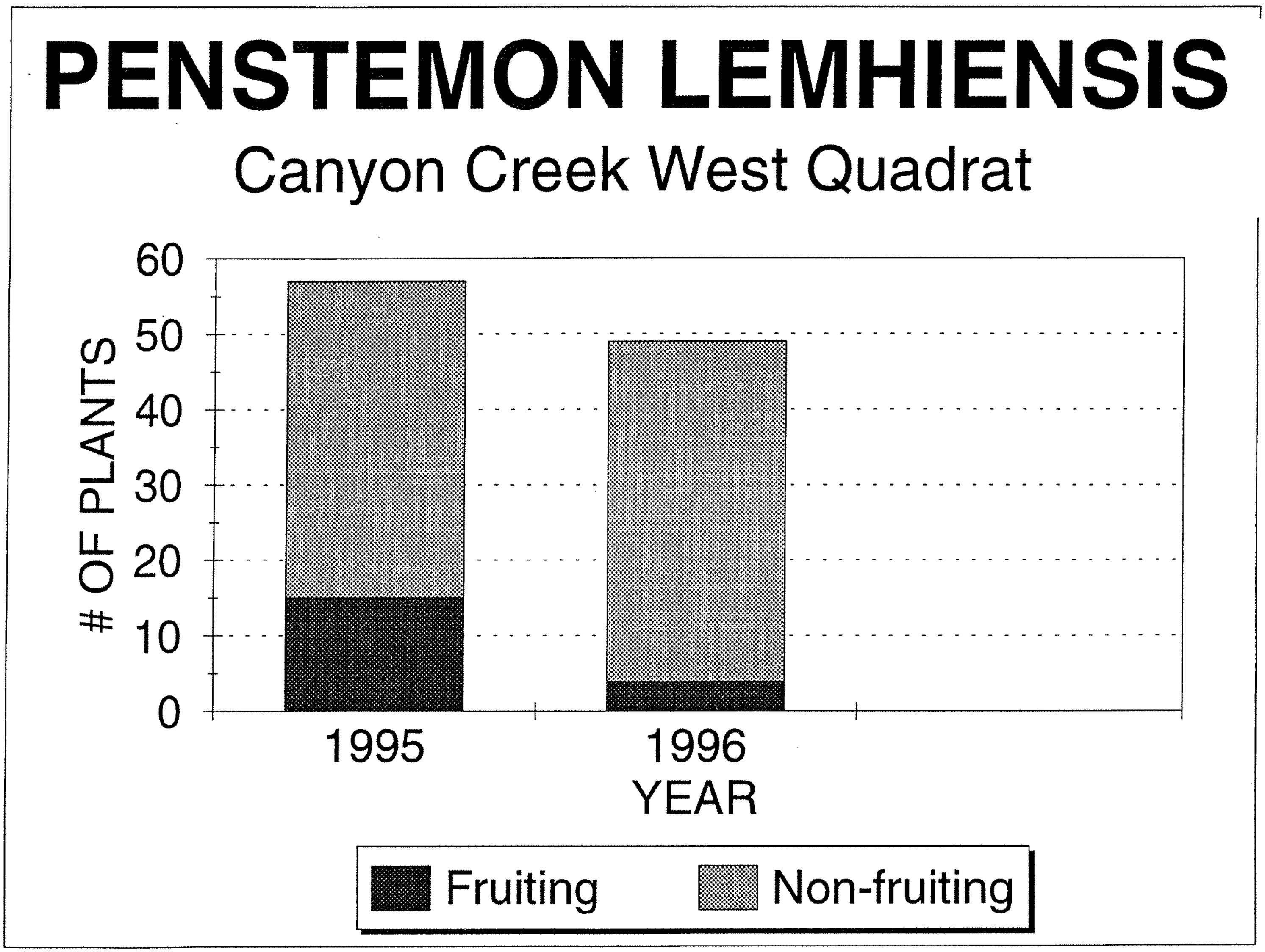


PENSTEMON LEMHIENSIS
Badger Pass North
OF PLANTS
120
100
80
60
40
20
0
1989
1990
1991
1992
1993
1994
1995
1996
YEAR
Fruiting
Non-fruiting
Seedlings



PENSTEMON LEMHIENSIS
Badger Pass North - Quadrat
25
20
15
10
5
0
OF PLANTS
1995
1996
YEAR
Fruiting
Non-fruiting


PENSTEMON LEMHIENSIS
Canyon Creek East Quadrat
OF PLANTS
25
20
15
10
5
0
1995
1996
YEAR
Fruiting
Non-fruiting


PENSTEMON LEMHIENSIS
Canyon Creek West Quadrat
60
50
40
30
20
10
0
OF PLANTS
1995
1996
YEAR
Fruiting
Non-fruiting

Appendix E. Raw data for *Penstemon lemhiensis* monitoring - 1995 and 1996

BADGER PASS MICROWAVE TOWER - TRANSECT 1

Plot	1995	1996
2	a. R2	x
	b. R4-I2-F27-A80 (37)	x
	c. R5-I3-F17-A51-B1 (38)	R3
9	a. R10-A6-F49-A70 (35)	R5
	b. R1 (34)	R1
	c. C1	C1
	d. C1	C1
	e. C1	C1
11	a. R9-I2-F6-A10 (36)	R5
	b. R3-I1-F3-A10 (39)	R2
	c. R2-I1-F13-A18 (40)	R3

BADGER PASS MICROWAVE TOWER - TRANSECT 2

Plot	1995	
1	a. R4	R2
4	a. R5-I2-F18-A32	R3
	d. R4-I1-F20-A46	x
	e. S1	x
	f. S1-C2	x
5	a. R1	R1
	c. R1	R1
	d. R1	x
	e. R2	R2
	g. S1	x
9	a. R3	R1
	b. R1	R1
	c. R3	R3
	d. R2	R2
	e. R4	R4I1A1
10	a. R2 (41)	R2

	b. R2-I1-F5-A4 (42)	x
	c. R1 (43)	x
	d. R1	x
	e. R2	x

BADGER PASS MICROWAVE TOWER - TRANSECT 3

Plot	1995	
2	a. R10-I2-F9-A16 (30)	R10I1F0
	b. R7-I1-F29-A18 (29)	R5I4F7A17
	c. R1	x
3	b. R8-I1-F17-A13 (24)	R4I1F0
	c . R4 (27)	R4I2F0A11
	d. R4-I2-F22-A21 (23)	R3I2F5A17
	e. R8-I-F58-A61 (22)	R3I1F2A6
	f. R5	R7I2F1A2
	g. R1	R1
	h. R1	R1
	j. R11 (26)	R5
	k. R7-I3-F41-A22	R3I2F8A4
	l. R3	R2

BADGER PASS MICROWAVE TOWER - QUADRAT (OUTSIDE EXCLOSURE)

Plot	1995	
1,1	a. R1-I2-F21	R1
	b. R1-I2-F27	x
6,4	a. R4-I3-F40	R4I1F8
9,7	a.	R3
9,9	a. R5-I2-F42	R3I1F12
10,9	a. R8-I4-F127	R6I1F5

BADGER PASS MICROWAVE TOWER - MARKED PLANTS IN EXCLOSURE
(partially overlaps with transects 1-3, above)

Group 1

1	Dead	-
2	R3	R2
3	R2	R2
4	R2-I1-F7-A20	R2
5	R11-I7-F113-A158	R18I2F23A16
6	R1-I1-F5-A4	R1

Group 2

7	R10I1-F4-A3	R1
8	R3-A1	R3
9	R2	R3
10	R3	R1I1F4A8
11	R3	R3
12	R3-I2-F13-A25	x
13	R5-I2-F24-A30	R4I2F3A31
14	R5-I1-F26-A3	R3
15	R6-I3-F25-A51	R5I1F0A15
16	R13-I8-F0-A360	R3
17	R8-I2-B2-F1-A116	R3
18	R10-I3-F0-A140	R4I2F0A28
19	Dead	-
20	-	-
21	-	
22	R8-I5-F58-A61*	R3I1F2A6
23	R4-I2-F22-A21*	R3I1F2A6
24	R8-I1-F17-A13*	R4I1F0
25	-	
26	R4*	R5
27	R4*	R4I2F0A11
28	-	-
29	R7-I1-F29-A18*	R5I4F7A17
30	R10-I2-F9-A15*	R10I1F0
31	R7-I2-F42-A76	R4I1F1A8
32	R5-I1-F4-A20	R4

Group 3

33	Dead*	-
34	R1*	R4
35	R10-I6-F49-A70*	R5
36	R9-I2-F6-A10*	R5
37	R4-I2-F27-A80*	x
38	R5-I3-F17-A51-B1*	R3
39	R3-I1-F3-A10*	R2
40	R2-I1-F13-A18*	R3
41	R2*	R2

42	R2-I1-F5-A4*	x
43	R1*	x
44	Dead	-

*Asterisked plants are also in the belt transects

BADGER PASS NORTH - BELT TRANSECT

Plot	1995	1996
2	m. C1	x
31	c. R1	R1
	f. R1	R1
32	a. R1	x
35	c. R2	R3
41	j. C1	R1
	n. C1	R1
43	k. S1	x
	l. C1	R1

BADGER PASS NORTH - QUADRAT

Plot	1995	
2,7	a. R7-B2-I5-F19	R7
	b. C1	x
2,9	a. R1	R3
3,7	a. R4-I3-F8	R5
3,8	a. C1	R1
	b. R2	x
3,9	a. R1	R5
4,7	a. C1	x
	b. C1	x
4,8	a. C1	x
4,9	a. R3	R3
5,10	a. R6	R11I1B1
6,10	a. R4	R11I1B1
	b. C1	R1
7,8	a. R1	x

7,10	a. R12I3F34	R28I7B1F47A7
	b. R1	R5
	c. R2	R7I1B1
8,10	a. R2	R1
	b. R1	R1
9,8	a. R1	R1
10,4	a. R2	R10

CANYON CREEK - EAST QUADRAT

Plot	1995	1996
1,3	a. R1	x
	b. R4-I1-F71	x
	c. -	S
1,5	a. R1	x
	b. -	R3
1,6	a. R1	x
1,10	a. R3-I2-F22	x
2,1	a. R1-I1-F6	R1
	b. S	S
2,2	a. R1	R1
2,7	a. R2-I1-F9	R2
3,2	a. R1	R1
	b. R1	x
3,3	a. C1	x
3,4	a. R4-I2-F11	x
3,9	a. R1-I1-F12	R3
	b. -	S

4,3	a. R2-I1-F9	x
4,8	a. R2-I1-A1	x
5,5	a. R1-I1-F12 b. R4	R1I1F2 R3I2F18
5,8	a. R2-B1	x
8,8	a. R6-I1-A1 b. R1	x R1
8,5	a. R1	x
9,4	a. R2-I2-F14	R5I3F10
9,5	a. -	R1

CANYON CREEK - WEST QUADRAT

Plot	1995	1996
2,7	a. R4-I3-F62	R4
2,9	a. R1	R2
2,10	a. R1 b. R4-I1-F8	x R4
3,4	a. -	S
3,6	a. R1 b. R8-I3-F48	R4 R4
3,8	a. - b. -	R1 S
3,10	a. R1	x
4,1	a. R1 b. R1	x R2
4,4	a. R1	x
4,5	a. R4-I1-F7	R5

	b. R7-I3-F36-B2	R7
	c. S	x
4,8	a. R4-I1-F18	R2
	b. R1	R1
4,9	a. R1	x
	b. R4	R3
4,10	a. R1	x
	b. R2-I1-F8; C1; S1	x
	b1. S	x
	b2. C	S
	c. R3-I1-F9	x
	d. R2	R4
	e. R4-A1; S1	R6
	e2. S	R2
	f. R2	R1
	g. R2	S
5,1	a. R2	x
5,2	a. R1	x
	b. -	R2
	c. -	R2
5,3	a. -	R2
5,5	a. R1	R3
5,9	a. R1	R3
	b. R1	R1
6,1	a. R1	x
	b. -	R1
6,4	a. R1	R2
6,5	a. R1	R2
6,8	a. R2	R2
	b. -	R2
6,10	a. R1	R1

7,3	a. R3	R2
	b. R8-I1-F4	x
7,7	a. R1	x
7,8	a. R5I2F18; S1	R5
	a2. S	x
	b. -	R1
	c. -	S
7,9	a. R2	R2B1
7,10	a. R1	R2
	b. R1	R2
8,3	a. R3	R2
	b. R8	R4
8,6	a. R3	x
8,7	a. R1	R2
	b. R1	R2
	c. R5	R1
	d. R3-I2-F14	x
8,10	a. R5	R3
9,1	a. R1-I1-F5; S1	R1
	a2. S	x
	b. R2	R3
9,3	a. R1-I1-F8	R3
9,7	a. R1	R1
9,8	a. R1	R2
9,10	a. R1	x
	b. -	S
10,7	a. R1	R3I3A1B2
10,8	a. R3	R2I1A1
10,9	a. -	R2
10,10	a. R6-I1-F5; C1	R5I3A3
	a2. C	x

Appendix F. Spreadsheet data for *Penstemon lemhiensis* fire response monitoring, 1995-1996

Oversize sheets are attached separately

Appendix G. Summary statistics for monitoring *Penstemon lemhiensis* fire response - 1995

	Badger Pass Microwave	Badger Pass Microwave Quadrat	Badger Pass North	Badger Pass North Quadrat	Canyon Creek - East Quadrat	Canyon Creek - West Quadrat
# of plants/ set	41	5	6	23	22	57
# of seedlings/ set	3	0	0	(0)	(0)	(5)
total # of plants/ set	44	5	6	23	22	62
density plants/m2)	1.7	0.05	0.12	0.23	0.22	0.57
# of reprod. plants/set	15	5	0	3	11	15
% reprodt. plants	37	100	0	13	450	26
total # inflor.	28	13	0	11	15	23
av. # inflor./rep. plant	1.9	2.6	-	3.7	1.3	1.5
# of flowering stems browsed	1	0	0	1	1	0
% of flowering stems browsed	4	0	-	10	9	-
# of plants w/ only aborted flowers	0	0	-	0	2	1

# aborted flowers	461	0	-	-	2	1
av. # aborted flowers/ inflor.	31	-	-	-	1	1
% aborted flowers	58	-	-	-	1	7
# plants fruiting/ set	15	5	0	3	9	14
% plants fruiting	37	100	0	13	39	23
# fruits/ set	334	257	0	61	166	250
# fruits predated	0	0	-	0	0	4
mean # fruits/plant	22	51.4	-	20.3	18.4	17.9
mean # fruits/ inflor.	9.8	19.8	-	5.5	11.9	10.9
# R1 plants	11	2	4	6	10	29
# R2+R3 plants	10	0	1	6	7	13
# R4-R6 plants	9	2	0	3	4	10
# R7+ plants	8	1	0	1	0	4
# R1 plants w/ inflor.	0	2	0	0	2	2
# R2+R3 plants w/ inflor.	3	-	0	0	6	3

#R4-R6 plants w/ inflor.	5	2	-	2	3	6
# R7+ plants w/ inflor.	7	1	-	1	-	3
% of plants w/ R1	27	40	66	26	45	51
% of plants w/ R2-R3	24	0	12.5	26	32	23
% of plants w/ R4-R6	22	40	0	13	19	17
% of plants w/ R7+	20	20	0	4	0	7
% of R1 w/ inflor.	0	100	0	0	20	7
% of R2+R3 w/ inflor.	27	-	0	0	86	23
% of R4-R6 w/ inflor.	55	100	-	33	75	70
% of R7+ w/ inflor.	87	100	-	100	0	75

Appendix H. Summary statistics for monitoring *Penstemon lemhiensis* fire response - 1996

	Badger Pass Microwave	Badger Pass Microwave Quadrat	Badger Pass North	Badger Pass North Quadrat	Canyon Creek - East Quadrat	Canyon Creek - West Quadrat
# of plants/ set	30	5	6	17	12	49
# of seedlings/ set	0	0	0	0	1	4
total # of plants/ set	30	5	6	17	13	53
density plants/m2)	1.1	0.05	12	.17	0.13	0.53
# of new plants/ set (R1 and C1)	1	0	0	0	1	3
# of new plants/ set (>R1)	1	1	0	1	1	6
total recruitmnt	2	1	0	1	2	9
# establ. plants not surviving	9	1	2	7	13	17
# R1 plants dying	3	1	2	1	5	11
# R2+R3 plants dying	3	0	-	1	4	4
#R4-R6 plants dying	2	0	-	0	3	-

#R7+ plants dying	-	0	-	0	-	2
# of reprod. plants dying	3	1	0	0	4	14
% of R1 plants dying	27	50	50	12.5	50	38
% of R2+R3 plants dying	14	-	0	12.5	57	28
% of R4-R6 plants dying	18	-	-	-	50	0
% of R7+ plants dying	-	-	-	-	-	0
% of reprod. plants dying	20	20	0	0	54	27
# of seedlings surviving	0	-	0	-	1	1
% of seedlings surviving	0	-	0	-	100	25
# of reprod. plants/set	9	3		4	3	3
% reprodt. plants	30	60	0	23	23	6
total # inflor.	16	3	0	10	6	7

av. # inflor./rep. plant	1.9	1	-	2.5	2.0	2.3
# of flowering stems browsed	0	0	-	4	0	3
% of flowering stems browsed	-	-	-	40	-	43
# of plants w/ only aborted flowers	2	0	-	0	0	0
# aborted flowers	58	-	-	7	-	5
av. # aborted flowers/ inflor.	3.6	-	-	1.7	-	1.2
% aborted flowers	72	-	-	13	-	100
# plants fruiting/ set	5	3	0	1	3	0
% plants fruiting	17	60	-	6	23	-
# fruits/ set	23	25	-	47	30	-
# fruits predated	0	8.3	-	0	0	-
mean # fruits/plant	4.6	8.3	-	47	10	-
mean # fruits/ inflor.	1.4	8.3	-	6.7	5	-

Appendix I. Summary statistics formulas

PENSTEMON LEMHIENSIS MONITORING

Stat. as currently labelled	Stat. calculation
"# of plants/ transect"	= Total no. of plants represented in the "CO" (count) column (**Not** the sum of values in the CO column)

(This is the number of *established* plants, i.e., everything except for seedlings.)

"# of seedlings/ transect"	= The sum of values represented in the "TS" column
total # of plants / transect	Sum of the previous two tallies
density	= Total number of plants (CO) per sampling area, with The sampling areas for the six sample sets as follow: Badger Pass Microwave exclosure belts (26 m2) Badger Pass Microwave macroplot (100 m2) Badger Pass North belt (50 m2) Badger Pass North macroplot (100 m2) Canyon Creek East macroplot (100 m2) Canyon Creek West macroplot (100 m2)
# of new plants / transect (R1 and C1)	= Total number of plants that became R1 or C1 from a seedling (TS) the previous year or other plants that appeared without any prior mapped presence
# of new plants / transect	= Total number of plants that became at least R2 from (Greater than R1) a seedling the previous year or other plants that appeared without prior mapped presence
Total recruitment	= Total of seedlings + new plants (both categories)/transect
# establ. plants not surviving	= The number of plants represented in the "CO" column the previous year that are subsequently dead

Note: The following 10 calculations are subsets of the preceding mortality figure

# of one-rosette plants not surviving
# of 2-3 rosette plants not surviving
# of 4-6 rosette plants not surviving
# of 7+ rosette plants not surviving
# of reproductive plants not surviving
% of 1 rosette plants not surviving
% of 2-3 rosette plants not surviving
% of 4-6 rosette plants not surviving
% of 7+ rosette plants not surviving
% of reproductive plants not surviving

# of seedlings surviving from the previous year	= Total number of plants represented in any column that were seedlings (TS) during the previous year
% of seedlings surviving from the previous year	# survivors/total # of previous year seedlings
# reproductive plants/ transect	= Total number of plants represented in the "I" column

% reproductive plants	= % reproductive plants compared to total no. of established plants
Total # infloresences	= Sum of values in the "I" column
Average # infloresences per reproductive plant	= Total # infloresences/ # reproductive plants
# of flowering stems browsed	= Sum of values in the "B" column
% of flowerings stems	= Total # of browsed stems/ Total # infloresences
# of plants with only aborted flowers	= Total # of plants with values in the "A" column but none in the "F" column
# aborted flowers	= Sum of values in the "A" column
Average # aborted flowers/infloresences	= Total # aborted flowers / total # of infloresences
% aborted flowers	= Total # aborted flowers/ total # mature + aborted fruits
# plants fruiting/transect	= Total # of plants with values in the "F" column
% plants fruiting	= Total # plants fruiting/ total # of established plants
# fruits / transect	= Sum of values in the "F" column
# fruits predated	= Sum of values in the "P" column
mean (av.) # fruits/plant	= total # fruits/ total # of fruiting plants
mean # fruits/infloresence	= total # fruits/ total # infloresences
# of plants w/ 1 rosette	
# of reproductive plants with 1 rosette	
# of plants w/ 2-3 rosettes	
# of reproductive plants with 2-3 rosettes	
# of plants w/ 4-6 rosettes	
# of reproductive plants w/4-6 rosettes	
# of plants w/ 7-10 rosettes	
# of reproductive plants w/ 7-10 rosettes	
# of plants w/ > 10 rosetttes	
# reproductive plants w/ > 10 rosettes	
% total plants w/ 1 rosette	

% plants w/ 2-3 rosettes

% plants w/ 4-6 rosettes

% plants w/ 7-10 rosettes

% of plants w/ >10 rosettes

% of 1-rosette plants tat are reproductive

% of 2-3 rosette plants that are reproductive

% of 4-6 rosette plants that are reproductive

% of >7 rosette plants that are reproductive

% of reproductive plants with 1 rosette

Appendix J. Results and Interpretation for *Penstemon lemhiensis* chilling experiment

Concurrent seed biology research was initiated in 1995 to understand the critical seedling establishment phase of the life cycle and factors affecting it. Seed-containing capsules were collected from the Badger Pass Microwave and Canyon Creek sites used in this project, and Robbins Gulch in the Bitterroot National Forest. Collections were made in August 1995. Seed material was sent to Dr. Susan Meyer, Research Ecologist in the USDA Forest Service Shrub Sciences Laboratory in Provo, UT who has build up a large body of information about seed biology of the *Penstemon* genus (Meyer et al. 1995).

In an effort to determine the conditions under which seeds germinate, seeds from the three sites were put under two sets of conditions:

- Variable chill duration treatments (0-24 weeks), and
- Variable timing of a warm treatment interruption in a 20 week chill treatment.

The *Penstemon lemhiensis* seed biology study results and interpretation produced by Meyer (1996) are presented on the following pages. The potential implications of prescribed burn are addressed here.

Germination ranged between 0-33.3% of total viable seed depending on treatment, with the remainder of the seeds staying dormant. All seeds required chill treatment regardless of source, which is taken to mean that all seeds are dormant in the fall and less affected by fire than emerging seedlings. Fire will consume any standing dead plant material such as the flowering stalk, but mature capsules shatter easily late in the season, and are dispersed by September. Nevertheless, there will be seed ignition and loss among those that fall on flammable surfaces.

There was a correlation between elevation and an early warm treatment in bringing low elevation seeds out of dormancy. These results indicate that germination beneath the snow followed by spring emergence is the norm for *Penstemon lemhiensis* (Meyers 1996), a pattern which is generally compatible with fall burn treatment.

This study indicates that the majority of seeds produced annually remain dormant for over one year. The mechanism for release from dormancy is not known. The size of the seedbank is not affected by fire. The longevity of seedbank dormancy will be examined separately in the coming months by comparing seeds collected at the French Creek site in 1988 and put under cold storage with those collected in 1996; a study being conducted by the USDA Bridger Plant Materials Center.

Results of *Penstemon lemhiensis* chilling experiment - 1995 seed collections

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Table 1. Final post-incubation germination percentages following chilling periods of 0 to 24 weeks, expressed as percentage of viable seeds. Seeds were moist-chilled at 2C in the dark and then incubated for four weeks at 10/20C (12h:12h) with cool-white fluorescent light during the high temperature part of the cycle.

Population	Chilling Duration (Weeks)						
	0	4	8	12	16	20	24
Robbins Gulch	0b	0b	1.1b	1.1b	21.7a	19.8a	22.6a
Badger Pass	0c	0c	1.0c	3.1c	11.7b	23.2a	25.8a
Canyon Creek	0b	0b	0b	4.0b	28.9a	26.5a	21.6a

Within a population, means followed by the same letter are not significantly different at the p<0.05 level according to an LSD test.

Table 2. Final post-incubation germination percentages following a chilling period totalling 20 weeks, preceded or interrupted by incubation at 10/20C for 4 weeks and followed by incubation at 10/20C for 4 weeks, with 20-week chill without prewarm or interrupt-warm as a control treatment. (These treatments were generated by returning petri dishes from chilling treatments 0-16 weeks to chilling after their 4-week incubation at 10/20C, for a period sufficient to give them a total of twenty weeks of chilling).

Population	Chilling Treatment (Weeks Chilling=Ch; Weeks 10/20=Wm)					
	4Wm+ 20Ch	4Ch+ 4Wm+ 16Ch	8Ch+ 4Wm+ 12Ch	12Ch+ 4Wm+ 8Ch	16Ch+ 4Wm+ 4Ch	20Ch
Robbins Gulch	27.6a	11.5c	4.3d	1.1d	21.7ab	19.8b
Badger Pass	17.2a	1.0b	1.0b	3.2b	11.7	23.2a
Canyon Creek	6.4b	3.8b	9.3b	4.0b	33.3a	26.5a

Within a population, means followed by the same letter are not significantly different at the P<0.05 level according to an LSD test.

Penstemon lemhiensis germination data interpretation:

Seeds of this species behaved similarly to seeds from other mid-elevation montane penstemon species in the Intermountain West (see Meyer, Kitchen, and Carlson 1995, enclosed). The three collections showed similar chilling responses (see Table 1). Seeds required at least 16 weeks of chilling to become germinable to any significant degree. Chilling beyond 16 weeks caused no further increase in germinable seed percentage for the Robbins Gulch and Canyon Creek collections, while the Badger Pass collection showed an increase with up to 20 weeks of chilling.

Over 90% of the seeds that responded to chilling actually germinated during chilling period. Only 20-25% of the seeds were chill-responsive; the remaining 75-80% did not lose dormancy in chilling regardlless of chilling duration. These seeds would presumably not germinate in the field the first year. In retrieval experiments with penstemon seedlots that contained an initially chill-nonresponsive fraction, some seeds remained dormant in the seed bank for at least six years. The processes by which these seeds eventually lose dormancy are not known.

Prewarming and chill interruption results with this species also parallel those observed for other penstemon species (see Table 2). The effects of chilling are generally not 'remembered' across periods of chilling interruption, even though the seeds remained imbibed. The effect of a prewarm treatment before chilling was not dramatic in these collections, but the three collections did show contrasting responses. Robbins Gulch seeds showed an increased germination percentage with prewarm in comparison with the 20-week control, while the Badger Pass collection showed no significant effect and the Canyon Creek collection showed a significant decrease. These results reflect the possible effect of time spent imbibed after seed maturation in summer but before the onset of temperatures low enough to effect a chilling response.

In summary these results indicate that germination beneath the snow followed by spring emergence is the norm for this species as it is for most other montane penstemons, and that seeds would be expected to to carry over across years as a persistent seed bank.

Appendix K. Checklist of monitoring field supplies

- All results from the previous year as transcribed in the field onto data sheets

- Blank data sheets formatted for both belt transects and quadrats

- Camera in years following burn treatment (SLR; 25 mm lens)

- Ecodoata form in years following burn treatment

- Clipboard(s)

- Compass

- Maps showing study site locations (from this report or annotated MTHP topographic maps)

- Meter sticks, two

- Metric tapes, three 30 m

- Rain gear

- Sledge hammer and spray paint for loose or fading rebar